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COUNCIL ON COMPETITIVENESS

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INDUSTRY AS A CUSTOMER OF THE FEDERAL LABORATORIES

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FOREWORD

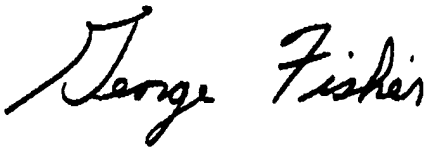
In many ways, the Federal laboratories are a microcosm of the broader competitiveness challenges facing the United States. Set up at different times to accomplish different missions, they are geared more to the Cold War era that is behind us than to the era of intense international economic competition in which we now find ourselves. Like many of the policies and institutions that were developed during the post-war period, much of the work at the labs needs to be refocused to address contemporary problems.

Refocusing the activities of the Federal labs, however, entails risk as well as opportunity. Risk, in that they constitute a major national resource which could be squandered if we fail to manage the transition appropriately. Opportunity, in that they represent important capabilities which can be harnessed to strengthen U.S. industry's technological performance.

It is essential that U.S. policymakers, the business community and the labs themselves approach this transition with a strategy and realistic expectations, instead of just letting it happen. There is no doubt that the United States should make every effort to enhance laboratory-industry cooperation in the years ahead. The national investment that we have made in these facilities is simply too great to ignore. But we must not let the need to refocus the labs cloud our view of the contribution that they can realistically make to U.S. industrial performance. Many business executives doubt that U.S. industry will derive significant new technological benefits from the Federal labs and caution against holding up technology transfer from the labs to industry as the answer to our competitiveness problems. To do so would not only be unrealistic, but also could ultimately create deep cynicism about the prospects for technology transfer.

Instead, we must have a clear view of what joint industry-laboratory cooperation can offer. It is a means of helping companies take advantage of the technical expertise that the Federal labs have developed in pursuit of their primary missions. It is not a justification for maintaining the labs' current staffing levels and programs; it is not a carte blanche for the labs to expand into new activities for which they have little experience without the close involvement of industry; it is not the answer to the much deeper problem of defense conversion; and it is not a way to avoid the need to close and consolidate some labs in order to free up funds for more urgent programs.

The analysis and recommendations that follow focus on how to improve the management of the technology transfer process and how to redirect about $1 billion of lab funds. The report does not deal with the $5 to $8 billion of the total defense R&D budget that may be affected by cuts, nor does it justify or lay out a plan for dealing with the totality of the government's investment in all of the Federal labs. By outlining some steps that we can take today to facilitate joint industry-lab technology partnerships, however, this report lays the groundwork for immediate action and sets the stage for future progress.



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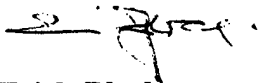

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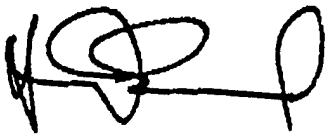

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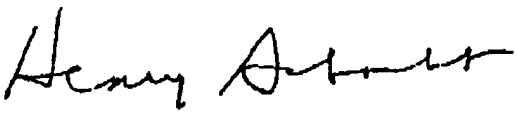

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The Council's university vice-chairman, Thomas E. Everhart (President, California Institute of Technology), presently chairs the Secretary of Energy Advisory Board. To avoid any perception of conflict of interest, he has abstained from approving this report.

EXECUTIVE SUMMARY

The Federal labs have a new customer -- U.S. industry -- and need to develop customer-driven technology transfer programs to service its needs. Despite widespread recognition of this fact, however, progress has been slow. This paper explores the opportunities and barriers facing industry and the Federal labs, especially DOE and NASA, as they attempt to establish new partnerships. Two themes run through this report. First, the authority to negotiate, sign, fund and implement cooperative technology ventures with industry should rest with individual labs -- not Congress, their Federal agencies or intermediary technology transfer centers. Second, technology transfer does not require new funds, but a reprioritization of existing funds.

The report concludes with nine recommendations to make technology transfer work. These recommendations do not address all of the challenges facing the Federal labs, nor do they represent a definitive solution to the problem of how to manage industry-lab cooperation. Instead, they are steps that we can take today to achieve some concrete results. The recommendations, which are discussed in detail on pages 14-17 of the report, are summarized below. They can be divided into three categories: 1) funding and focus of the labs, 2) management of the labs and 3) industry initiatives.

FUNDING AND FOCUS OF THE LABORATORIES

1. Congress and Executive agencies should assign 10% of the budget of DOE and NASA labs to joint civilian technology programs with industry, and give lab directors greater discretion in allocating their budgets to technology transfer projects. This share should be increased to 20% over the next few years and should perhaps go even higher, depending on the labs' performance and our experience with technology transfer efforts.

2. The Federal government should launch national technology infrastructure programs that strengthen U.S. industrial competitiveness and foster cooperation among industry, universities and the Federal labs.

MANAGEMENT OF THE LABORATORIES

3. Congress and Executive agencies should give the directors at government-owned-contractor-operated labs full legal authority to negotiate, sign, execute and fund cooperative R&D ventures with industry.

4. The Department of Defense should establish an outreach program to make the R&D and technical expertise in DOD labs more accessible to civilian industry.

5. The Federal labs should work closely with state technology development programs and non-profit technology consortia in their technology transfer efforts.

6. Congress and Executive agencies should encourage non-DOD labs to establish industrial advisory committees to assist in the planning and execution of programs related to technology transfer and the use of discretionary funds for partnerships with industry.

7. Industry and the Federal labs should jointly establish metrics to determine how well the technology transfer process is working and review progress after 3-5 years. If insufficient progress has been made, both industry and the labs should reevaluate their involvement, and funds should be redirected to consortia, universities, non-profit research groups and other organizations that can work more effectively with industry for results.

INDUSTRY INITIATIVES

8. U.S. industry should work actively with the Federal labs and their Executive agencies to establish model and umbrella cooperative R&D agreements, and to maximize use of existing agreements.

9. U.S. industry should be a good customer of the labs -- demanding, committed and willing to work with them to improve the relevance of the labs' research.

INDUSTRY AS A CUSTOMER OF THE FEDERAL LABORATORIES

America's Federal laboratories have a new customer -- U.S. industry. They also have a new mission -- technology transfer. This new customer and new mission stand as clear reminders of the end of the Cold War. No longer is national security the overriding priority of the Federal labs; economic competitiveness must also become a vital consideration.

Nowhere is the shift from military to economic concerns more evident than in technology. Just as the need for a massive military arsenal is declining, the need for a strong knowledge base in commercial technology is increasing. Because defense R&D currently accounts for about half of the Federal labs' total budget, the shift away from military technology is creating enormous pressure on the labs to redirect or consolidate many of their defense-related programs.

The need to enhance America's industrial competitiveness stands out as a major opportunity to redirect some of the labs' technical capabilities toward a new national goal. It is important to note, however, that making the labs more responsive to the needs of industry is not a panacea for the broader problem of how to manage cuts in defense spending that will result from the end of the Cold War.

The competitiveness agenda will require new attitudes and operating procedures on the part of both the Federal labs and U.S. industry. The challenge facing the labs is how to apply their technical talent to issues that are critical to U.S. economic competitiveness. The labs must create a better working relationship with industry, make sure that their research is relevant to industrial concerns and assure that the results of their research are quickly transferred to the private sector. The challenge facing industry is how to help focus R&D at the labs so that it is appropriate to industrial needs, how to structure joint technology development programs and how to access R&D at the labs.

It is incumbent on U.S. industry and the labs to work together to shape this agenda. The labs are increasingly open to working with industry. Moreover, recent legislation gives industry the ability to structure productive new relationships with the labs. Industry should seize the opportunity to leverage lab assets to complement its own research activities.

There is a danger, however, that the possibility for more meaningful industry-lab interaction may be lost before constructive programs can be put in place. Many of the labs are having difficulty serving the needs of industry while fulfilling their traditional missions. Some of these difficulties are to be expected. The labs are being called on to undertake activities for which they have little prior experience, and it is only natural for initial progress to be slow.

There are also some deeper problems. Viewing industry as a customer of the labs is not as simple as it sounds. Although the labs are attempting to become more attuned to industry's needs, their primary responsibility remains to their Executive agencies and to Congress, neither of which has made it clear what they expect from the labs beyond their original mission with respect to industrial interaction, nor followed up with more flexible delegation of authority.

Even if the labs did focus on industry as a primary customer, they would have to overcome the fact that they were not set up to promote commercial technology and that their culture and direction are not structured around strengthening national economic performance. Although the government agencies that administer the labs are vocal in their support of technology transfer, many of them are reluctant to make the changes in their management practices and budget priorities that are necessary to promote it effectively. Industry must also share part of the blame. All too often, industry has moved too slowly in harnessing the labs' potential for developing new technology with commercial applications and has failed to take full advantage of new legislation.

As a result of these problems, there has been slow progress in industry-lab cooperation. Industry criticizes the labs for failing to understand the driving forces and boundary conditions that are important in commercial markets and failing to appreciate the premium on rapid cycle-time. The labs criticize industry for its lack of patience and its unwillingness to work closely with them for results. And everyone criticizes the Federal bureaucracy for a lack of committed resources, too much red tape and not enough flexibility or decentralized decision-making.

There are different opinions in industry about the ability of the Federal labs to make a significant contribution to U.S. industry's technology needs. Some believe that it is a mistake to ask the labs to become too deeply involved in technology transfer. They insist that the labs were not set up to accomplish this mission and will inevitably do a poor job. Instead, they believe that the government should reduce the labs' overall budget and redirect the savings to organizations specifically designed to promote industrial technology, such as industrial R&D centers at universities and private sector research organizations, or give the savings directly to industry in the form of R&D tax credits.

We view the problem from a different perspective. The Federal labs constitute a wealth of technical talent, and some represent world-class facilities that do not exist in industry. They should be structured so that they directly address the needs of the civilian technology base. This means that a significant portion of their budget should be directed to R&D activities determined jointly with industry and conducted in close cooperation with industry. Moreover, their programs should be structured so that the private sector has easy access to their resources. The Federal labs cannot be all things to all people, but individual labs have great resources that industry should leverage. Meshing the core competencies of the labs with the technical needs of industry has the potential to provide significant benefits to the nation as a whole.

At the same time, however, it is important to recognize that technology transfer should not be viewed as a justification for simply continuing the labs' present staffing levels, or worse, their present programs. Nor should it be used as an excuse for the labs to move into new areas that are not part of their missions or to expand unilaterally into new fields of research. Instead, technology transfer should be viewed as a means of leveraging the technical expertise that the labs have developed in pursuit of their primary national mission (e.g. defense, energy, the environment).

The purpose of this paper is not to review the history of technology transfer at the Federal labs, or to examine broad questions about consolidation and defense conversion. Instead, the intent is to evaluate specific bottlenecks that are slowing progress and to identify opportunities that hold the potential for significant results. Working with the Federal government is not easy, and the structure, mission and administration of these laboratories varies greatly. Because of the difficulty of generalizing about all of these labs, much of the discussion in this report relates to DOE labs. Where generalizations can be made, however, the report will also address broader issues that affect all of the Federal labs.

The analysis will focus on five key questions: 1) Who are the Federal labs? 2) How effectively are they transferring technology? 3) What are the major opportunities? 4) What are the major bottlenecks? and 5) How can we improve the technology transfer process? These questions are addressed below.

I. WHO ARE THE FEDERAL LABS?

According to Allan Bromley, Assistant to the President for Science and Technology Policy, there are 726 Federal labs. In FY 1991 their combined budget was over $22 billion. These numbers have led some observers to assume that there is a vast network of technical expertise just waiting to be redirected to commercial purposes. This is not the case. Federal laboratories range from large organizations with 8-10,000 employees, such as Sandia and Los Alamos National Laboratories in New Mexico, to single-office facilities operated by a handful of people. The vast majority of the labs are small operations that employ 5-10 researchers and are located within a federal agency, a contractor or university. Moreover, the large labs focus primarily on basic research or very specialized applications. As a result, it is difficult to redirect their research toward industry's needs. Clearly, it does not make sense to treat the labs as generic centers of R&D or to insist that all of them adopt technology transfer as a priority focus. They vary enormously in terms of their missions, capabilities and flexibility.

In 1991, the agencies with the largest budgets for Federal laboratories were the Department of Defense ($7 billion), the Department of Energy ($6 billion), the Department of Health and Human Services ($3.4 billion, including the National Institutes of Health) and NASA ($3.3 billion). Federal appropriations for the Commerce Department's laboratory were only $183 million, but funding from industry and other agencies increased its total operating budget

to about $450 million.[1] The missions and funding for the labs reflect the priorities that guided the United States during the Cold War. DOD labs account for the single largest share of the total expenditures, and DOE labs, which spend half of their funds on military-related R&D, account for over 20% of the labs' budget. In other words, approximately one-half of the total funding for the labs is focused on military-related R&D. By contrast, Federal appropriations for the single Commerce Department laboratory (the National Institute of Standards and Technology), which is the only Federal lab whose principal mission is to assist industry, accounts for less than one percent of the total Federal lab budget. A summary of the key government agencies and their labs is provided on the following page.

[1] These amounts relate to R&D that is actually performed at the labs.

MAJOR EXECUTIVE AGENCIES AND THEIR FEDERAL LABS

The Department of Defense: DOD has just reorganized its 70-80 laboratories into a new framework that consists of 4 Air Force labs, 4 Naval Warfare Centers and the Naval Research Lab, and 19 Army labs. Total employment is approximately 60,000, which is the same level that existed prior to the reorganization.

The Department of Energy: DOE has 9 multi-program labs with about 51,200 employees and 12 major single purpose labs with about 20,000 employees.

NASA: NASA has 8 major labs and 2 special facilities labs with about 20,000 government employees and several times that in contractor support.

Health and Human Services: The largest and best known HHS lab is the National Institutes of Health, which consists of 13 different research institutes and several different centers and divisions that altogether have about 15,000 employees. The NIH budget last year was $9 billion, but about 80% of this total went to research conducted outside NIH.

Department of Commerce: DOC has one major laboratory, the National Institute of Standards and Technology, which employees about 3,000 people.

Department of Agriculture: USDA has 122 labs that employ 2,300 scientists.

Source: Interviews with lab directors and government officials.

II. HOW EFFECTIVELY ARE THE LABS TRANSFERRING TECHNOLOGY?

"Technology transfer" is the term most frequently used to describe efforts to find commercial applications for technology that is developed at the labs. Unfortunately, this term conjures up images of laboratories developing technology in isolation, then taking it off the shelf and supplying it to industry. This is a very narrow view of the process. Technology transfer consists of three different kinds of activities: 1) sharing technology that was developed to satisfy the needs of the lab's parent agency, but which also has relevance to commercial industry; 2) allowing industry to use lab facilities and testing equipment and to hire lab technical experts as consultants; and 3) having the labs and commercial industry jointly develop technology that meets industry-driven needs.

Different labs approach technology transfer in different ways. DOD labs focus on the first two activities, whereas DOC laboratories are involved in the last two categories and have focused on the third category as their principal mission. DOE labs are involved in all three activities, but are especially interested in the third. This paper will focus primarily on the third category.

Joint lab-industry development of technology consists of industry-driven, cost-shared partnerships that provide for protection of intellectual property. Unless industry is involved from the outset in the development of new technology and unless the labs are attuned to industry's technology requirements, technology transfer programs are unlikely to be successful. Even if the labs do create new technology with commercial potential, the difficulty of adapting it to industry's needs, making incremental improvements and phasing it into production schedules are major obstacles. In short, teamwork, not transfer, is the operative word.

During the 1980s, technology transfer gained prominence as an important priority for the Federal labs. Legislation was passed, Executive Orders were issued, and Agency priorities were changed. In 1980, the Stevenson-Wydler Act officially made technology transfer from the laboratories to private industry a policy of the Federal government. The 1986 Federal Technology Transfer Act authorized the establishment of cooperative research and development agreements (CRADAs) between government-operated labs and private industry. Executive Order 12591, which the President issued in 1987, directed agencies to delegate authority for entering into CRADAs to the laboratories and issued guidelines for intellectual property rights. The 1989 National Competitiveness Technology Transfer Act extended authority for entering into CRADAs to contract-operated government laboratories.

These laws have been parallelled by declarations of new laboratory missions, the establishment of technology transfer centers at many of the labs, and a proliferation of CRADAs and other cooperative R&D efforts. These efforts are long overdue. They have resulted in some successes, but overall progress has been slow and, so far, insufficient to meet the new technology challenges facing the United States.

This is not to say that there have not been examples of successful lab-industry cooperation. Over the years, the labs have made an important contribution to U.S. industrial competitiveness. The National Institutes of Health have helped make the U.S. pharmaceutical industry a world leader and helped spawn the biotechnology industry. Los Alamos National Lab has been instrumental in the development of supercomputer technology, providing invaluable assistance to such companies as Cray and Thinking Machines. Sandia National Lab has developed a very good working relationship with Sematech and helped developed new clean-room technology. Moreover, almost all of the major Federal labs can point to specific projects that have benefitted industry, such as Wright Laboratory's assistance to an automaker for its cruise control fuel system, or Jet Propulsion Lab's contribution to a small start-up environmental company for a toxic filtration system. Even more than these specific projects, however, what the major Federal labs offer is the capacity for large-scale, directed research in which a wide spectrum of technical disciplines can be integrated to solve specific problems.

Given increasing international competition in technology, however, the labs need to do much more. Today, there is often a tendency to confuse process with progress when assessing the labs' contribution to industry. Passing new legislation and renaming laboratory missions are not the same as developing technology that is relevant to industry and that companies can use in commercial markets. As proof of how much progress has been made, many analysts point to the fact that from September 1986 to 1991 almost 800 CRADAs were signed and that several hundred more have been signed since then, but many of these CRADAs have not been funded. Or they highlight the creation of new consortia as evidence of how effectively the labs are fulfilling their new mission, but these programs attest to agreements, not results. CRADAs may have been signed and projects launched, but, so far, very little technology that industry can actually incorporate into commercial products has been forthcoming.

Industry compares its relationship with the laboratories to its relationship with universities. During the past 5-10 years, industry has established closer ties to universities through joint research activities, personnel exchanges and new agreements for licensing and intellectual property protection, not to mention the traditional education

mission of the universities. All of these activities have helped strengthen industry's relationship with universities. Many industry executives believe that universities are much more flexible and less bureaucratic than the Federal labs. The comparison between universities and the labs demonstrates that the labs must do much more to establish close links with industry.

III. WHAT ARE THE MAJOR OPPORTUNITIES?

It is important not to lump lack of progress together with lack of potential and dismiss the labs' ability to make a significant contribution to U.S. industrial competitiveness. The Federal labs have enormous resources, and both government and the private sector should work to channel these resources. The end of the Cold War has forced the labs to reexamine their role and made them more open to working with the private sector, and the rise of international competition has forced industry to search out new partners and reexamine its relationship with the Federal labs. In the past year, General Motors, United Technologies/Pratt and Whitney, and the Computer Systems Policy Project have all held major conferences that brought the labs together with industry representatives to explore the feasibility of joint projects.

This new openness on the part of the labs and industry is complemented by the overlap between the labs' technical capabilities and industry's needs. As part of this project, the Council on Competitiveness conducted an informal poll in which it asked several companies to list the technical areas in which they needed assistance and asked several major labs to list those technical areas in which they had strong programs that they felt could assist industry. At a very general level, the match between industry's needs and the laboratories' capabilities was surprisingly close. The top four categories industry listed as critical to their needs were 1) advanced materials and processing, 2) advanced computing, 3) environmental technologies and 4) manufacturing processes, testing and equipment. The labs also highlighted each of these areas as their unique strengths. In addition, industry listed new power sources, sensors, photonics and optoelectronics as critical technologies. The Federal labs also have strong research programs in many of these areas. Clearly, there is extensive overlap between industry needs and laboratory capabilities.

Moreover, just like their counterparts in industry, scientists and engineers in the labs want to work on challenging projects and are highly motivated to pursue research that is both interesting and important. Consequently, the right set of incentives can go a long way toward making technology transfer a reality. Even when dollars do not change hands, technology transfer can be effectively accomplished by encouraging the transfer of people and the sharing of facilities.

It is also important to note that many of the Federal labs have excellent testing facilities and can play a major role in validating technology prior to the introduction of commercial products. Moreover, when it comes to mega-science and technology projects, the labs have an unparalleled capability to assemble experts, define technical roadmaps and mobilize resources.

In addition to the match of technical needs and capabilities, and the labs' unique resources, there has been important progress in developing a framework for cooperation. In the past, many proposed cooperative R&D programs have been stymied by legal barriers. Scientists and engineers may have been willing to cooperate, but lawyers and bureaucrats on both sides were not. Some of these obstacles have been overcome. For example, the Department of Energy has developed an umbrella CRADA with pre-approved terms and conditions with the National Center for Manufacturing Sciences and a pre-approved model CRADA with the Computer Systems Policy Project. These CRADAs create a streamlined framework for technology transfer that can be applied to DOE lab-industry joint R&D on manufacturing and computer technology. Hopefully, they will also serve as models for other agencies and industries and facilitate the process of technology transfer.

Finally, state technology programs have the potential to serve as effective intermediaries and promote constructive industry-lab partnerships. For example, the Edison Materials Technology Center in Ohio has 88 industrial and 13 university members. It provides contract R&D services and responds to requests for immediate help. In providing these services, it works closely with materials experts at Wright Laboratory and other Federal labs throughout Ohio.

IV. WHAT ARE THE MAJOR BARRIERS?

Based on current trends, only a small fraction of the Federal labs' resources will go to technology transfer activities during the next few years. This shift does not represent the kind of major reorientation of programs that is necessary, only a tinkering at the margins. It is clearly inadequate to meet the new industrial technology challenges facing the United States. There are several reasons for the disappointing progress.

First, technology transfer programs are inadequately funded, and, in the case of DOE, the labs do not even have the legal authority to redirect their existing budget to these activities. To the outside world, this lack of resources signals that technology transfer is not a priority. Instead of trying to reallocate existing budgets and priorities, the Federal labs tend to emphasize the need for additional funds for technology transfer. The private sector is skeptical of these requests for increased funding. Industry believes

that any new funds should go to organizations that are set up specifically to develop commercially relevant technology, not the Federal labs. Instead, Congress and the Executive agencies should direct the labs to shift funds out of programs that have achieved their missions or seen their mission requirements change and shift resources into programs that support U.S. industrial competitiveness.

Second, many labs tend to view issues related to industrial technology and competitiveness as peripheral concerns rather than as part of their core missions. Success in technology transfer is not included as part of the labs' reward system. Although some labs have embraced competitiveness as one of their priorities, many administrators and researchers feel threatened by this new goal and continue to conduct business as usual. As a result, technology transfer often fails to get the attention and resources it deserves. The labs cannot afford to view technology transfer as something that they do as an afterthought once they have fulfilled their primary mission; they must tackle industrial applications as an essential part of their mission.

Third, government bureaucracy too often slows down the approval process and needlessly complicates industry-lab partnerships. This problem is especially acute at the Department of Energy, where the inability to resolve differences between programs internally has severely hampered the approval process to date. For example, the 1989 National Competitiveness Technology Transfer Act was designed to give DOE lab directors the ability to execute CRADAs independently, but the legislation was interpreted by DOE to mean that although the labs can sign CRADAs, DOE must thoroughly review and approve them. This extra layer of bureaucracy significantly slows down the process of lab-industry collaboration. By contrast, Wright Laboratory (an Air Force laboratory) and the National Institute of Standards and Technology (a Commerce laboratory) have the authority to sign and execute CRADAs by themselves. In the case of the DOD labs, CRADAs that have been signed by individual lab directors automatically enter into force in 30 days unless higher authority specifically disapproves them during that period.

The DOE decision-making process is further complicated by too much paperwork. Because technology transfer is a priority mission for the Commerce Department, the National Institute of Standards and Technology can sign an umbrella agreement with industry, develop work statements of 1-2 pages for individual projects, and use its own discretion in funding them. DOE, by contrast, insists on a separate CRADA, typically 20-25 pages long, for each project and does not allow individual labs to fund collaborative projects with industry without DOE approval.

As a result of these practices, initial efforts at DOE to approve a CRADA took one to two years, compared to two weeks at NIST. This long delay is unacceptable to industry. Two years represents a lifetime in many fast-moving technology markets -- such as electronics where the typical product's life-cycle is 8-12 months -- so by the time DOE had approved a CRADA the company might no longer be interested in the technology. Fortunately, the process at DOE is presently improving. DOE has demonstrated that it can approve standard language CRADAs (i.e. with no deviations from the model) in a shorter time-frame.

Fourth, industry needs and laboratory capabilities are often not considered together in planning and executing programs. There is a tendency to look at technology transfer as either technology push in the form of research or technology pull in the form of specific industry requirements for new products. In fact, it is an interactive process requiring joint planning and execution. The needs and capabilities of both parties must be considered together at the outset rather than as serial problems after the program has been launched.

Fifth, there is a big cultural gap between the Federal labs and U.S. industry. The labs are technology-driven. They concentrate on developing enabling technologies that open the door for new capabilities and are concerned primarily with long-term responses to problems. Industry, by contrast, is market-driven. It concentrates on developing technologies with very specific product applications and is driven by the need for a short-term response to problems. The labs have grown up in an environment that focused on getting the job done, too often regardless of cost and the length of time it takes. Industry, by contrast, is frequently overly cost conscious and forgoes opportunities because of its short time horizon. While this difference in approach is not a problem in joint activities that are still at the level of fundamental research, such as is the case today with high temperature superconductivity, it becomes a major issue in R&D that is closer to potential product applications.

Sixth, the labs tend to focus on product characteristics and do not devote enough attention to reducing the costs of manufacturing processes or developing affordable tools. By contrast, industrial applications often have more to do with process innovation and cost-reductions than with improvements in product or material characteristics. This divergence is especially true in materials technology.

Seventh, the issue of the labs' R&D focus is complicated by the fact that if they get too close to industrial applications, they begin to compete unfairly with other private sector firms that are in the business of contract R&D. The laboratories should not be subsidized to compete with private sector research organizations and should not use technology transfer as a rationale to expand into areas outside of their competence.

V. HOW CAN WE IMPROVE THE TECHNOLOGY TRANSFER PROCESS?

There is more than enough criticism of the roles of the labs, government and industry in the technology transfer process. What is needed is to set some specific goals and to leverage assets to achieve them. There are several actions that can be taken to make the labs more responsive to industry's needs (i.e., more customer-driven). The primary objectives should be to decentralize decision-making, redirect resources toward technology transfer activities, and provide individual labs with greater autonomy to structure cooperative agreements with industry. If we are to achieve significant results, issues related both to funding and management must be addressed.

Specific recommendations are listed below. Some apply to labs in specific agencies; others apply to the Federal labs in general.

FUNDING AND FOCUS

1. Congress and Executive agencies should assign 10% of the budget of DOE and NASA labs to technology transfer programs, and give lab directors greater discretion in allocating their budgets to technology transfer projects. This share should be increased to 20% over the next few years and should perhaps go even higher, depending on the labs' performance and our experience with technology transfer efforts. Because technology transfer is often viewed as a peripheral activity at these laboratories, it receives only marginal support and funding. This situation will not change as long as DOE and NASA labs do not have significant budgetary authority for technology transfer. Ten percent of the budget of DOE and NASA labs is equal to just under one billion dollars. Insisting that technology transfer programs at DOE and NASA labs be industry-driven, cost-shared and collaborative would help make technology transfer a priority mission and assure its relevance to the private sector. As part of this budgetary realignment, lab directors should be given greater discretion in funding technology transfer projects out of their budget. The 1983 White House Federal Laboratory Review panel recommended that lab directors be given discretion over 5-10% of their annual budget -- a recommendation that we endorse. Nine years later, we are still a long way from this goal. A DOE lab-directed R&D order allows for up to 6% of the total operating costs of a facility to be directed to laboratory-initiated R&D programs. This precedent for allowing labs to provide for discretionary funding for basic research should be extended to joint civilian technology development programs with industry.

2. The Federal government should launch national technology infrastructure projects that strengthen U.S. industrial competitiveness and foster cooperation among industry, universities and the Federal labs. Promoting infrastructure projects that benefit the entire nation has long been a responsibility of the government. As the infrastructure needs of the U.S. economy become more technology-intensive, they provide a unique opportunity to leverage the capabilities of the Federal labs and structure closer partnerships with industry. Such technologies as information systems, advanced manufacturing systems, environmental technologies and certain materials are critical to the performance of many American industries. The government should work closely with industry to develop strategies for these technologies. Moreover, the government should strengthen such programs as NIST's Advanced Technology Program and Manufacturing Technology Centers, which are industry-driven and promote cooperation across different sectors of the economy.

MANAGEMENT OF THE LABORATORIES

3. Congress and Executive agencies should give laboratory directors at government-owned-contractor-operated labs full legal authority to negotiate, sign, execute and fund cooperative R&D ventures with industry. Many of the problems associated with technology transfer, especially at DOE labs, lie not with the labs themselves but with their Executive agencies. Individual lab directors at government-owned-contractor-operated (GOCO) labs should be allowed to structure, implement and fund cooperative R&D agreements (CRADAs) with industry without having to consult their Executive agencies. The directors of government-owned-government-operated (GOGO) labs already have this authority, but the directors of contractor-operated labs do not. For example, the directors of such labs as Sandia, Los Alamos and Oak Ridge do not have this authority and must submit all of their CRADAs to DOE for approval. By contrast, the directors of Wright Laboratory and China Lake can sign CRADAs on their own, which are then automatically implemented unless they are specifically disapproved by a higher DOD official within 30 days. The NIST CRADA approval process, however, is the most streamlined of all and is perhaps the best model for other Federal labs to follow. At NIST, there are eight or nine lab officials one level below the director who can approve and implement CRADAs by themselves. Consequently, NIST is very flexible and is able to respond quickly to industry's inquiries without bureaucratic interference.

4. The Department of Defense should establish an outreach program to make the R&D and technical expertise in DOD labs more accessible to civilian industry. Because DOD labs are required by law to focus on technology that is relevant to the nation's military needs, they cannot enter into joint agreements with industry to develop technology exclusively for commercial purposes. But DOD labs can take other kinds of actions to stimulate U.S. industrial competitiveness. First, they can transfer to industry technology developed for military purposes that may also have civilian applications. Second, they can let industry use laboratory facilities and testing equipment, and allow companies to consult with laboratory experts to help solve industrial problems. Many American companies are unaware of the facilities and technical expertise that exist inside DOD labs, and the DOD should develop an aggressive outreach program to give industry access to them.

5. The Federal labs should work closely with state technology development programs and non-profit technology consortia in their technology transfer efforts. The technology transfer activities of the labs can be significantly enhanced by linking them to other local technology commercialization networks. State technology programs provide a means to access the expertise of the labs and match it with industry needs. For example, the Edison Materials Technology Center ability to draw extensively on Wright Laboratory's technical capabilities for cooperative research and group problem-solving has appreciably enhanced its ability to serve the needs of local industry.

6. Congress and Executive agencies should encourage non-DOD labs to establish industrial advisory committees to assist in the planning and execution of programs related to technology transfer and the use of discretionary funds for partnerships with industry. NIST has had an outside Visiting Committee since 1901. In 1988, this group was changed to the Visiting Committee on Advanced Technology, and five of the nine members are required by law to come from industry. Oak Ridge, Los Alamos and Sandia National Labs have also added industrial representatives to their Director's advisory committees. Other labs should follow suit. These committees could take various forms, from broad oversight of a lab's technology transfer programs to review and critique of specific projects.

7. Industry and the Federal labs should jointly establish metrics to determine how well the technology transfer process is working and review progress after 3-5 years. If insufficient progress has been made, both industry and the labs should reevaluate their involvement, and funds should be redirected to consortia, universities, non-profit research groups and other R&D organizations that can work more effectively with industry for results. It is important to institute a

measure of accountability into the technology transfer process. If the nation is serious about having the labs work more closely with industry, it should give them full authority to do so and hold them accountable for results. If after 3-5 years the labs have not made a significant contribution to America's industrial technology needs, funds should be redirected to other organizations that are explicitly set up to accomplish this goal and have successful track records.

INDUSTRY INITIATIVES

8. U.S. industry should work actively with the Federal labs and their Executive agencies to establish model and umbrella cooperative R&D agreements and to maximize use of existing agreements. Model agreements with federal laboratories or agencies, such as model CRADAs and memos of understanding, help speed up the process of establishing research relationships with Federal labs. NIST has a very effective model CRADA that expedites its joint work with industry. The Department of Energy has developed umbrella CRADAs with the Computer Systems Policy Project and the National Center for Manufacturing Sciences to simplify and expedite cooperative R&D efforts between computer and manufacturing firms and DOE labs. These CRADAs address such key issues as proprietary information, U.S. preference for manufacturing, licensing, protection of software and intellectual property, and several other issues of importance to potential industrial partners. These agreements could be modified and implemented by any industrial concern interested in doing work with the Federal labs. Using them as a model could significantly help the private sector, since they contain the most comprehensive language on issues of concern to industry that DOE has approved so far.

9. U.S. industry should be a good customer of the labs -- demanding, committed and willing to work with them to improve the relevance of the labs' research. Industry should define R&D projects that would strengthen U.S. technological competitiveness and make a concerted effort to use the capabilities of the Federal labs in implementing these projects. Unless industry aggressively seeks out partnerships with the labs and helps structure meaningful R&D projects, technology transfer will remain a marginal aspect of the labs' programs and have little impact on America's technological competitiveness.

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Founded in 1986, the Council on Competitiveness is a nonprofit, nonpartisan organization of chief executives from business, higher education and organized labor who have joined together to pursue a single overriding goal: to improve the ability of America companies and workers to compete more effectively in world markets, while building a rising standard of living at home.

To build consensus within the public and private sectors on the actions needed to help Americans compete, the Council pursues a three part agenda: increase public awareness of the breadth and severity of America's economic problems; mobilize the political will required to set the United States on a positive economic course; and assist in the development of specific public policies and private-sector initiatives. To that end, the Council focuses on issues in the areas of fiscal policy, science and technology, international economics and trade, and human resources.

The Council is governed by an executive committee and draws on the resources of its national affiliates -- more than two dozen trade associations, professional societies and research organizations -- to help analyze issues and develop consensus. The Council is privately supported through contributions from its members, foundations and other granting institutions.

Note: The Council is often confused with two more recently established groups that have similar names, the President's Council on Competitiveness and the Competitiveness Policy Council. The Council is not affiliated with either of these other two groups. The President's Council was created by President Bush in 1989 and is chaired by Vice President Dan Quayle. It is a governmental interagency committee made up of Cabinet members and other heads of federal agencies. The Competitiveness Policy Council (CPC) is an independent advisory committee that was created by the Omnibus Trade and Competitiveness Act of 1988. It is composed of federal and state officials, as well as members from the private sector.

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